

The Genus *Pandanus* (Pandanaeae) On Christmas Island, Indian Ocean

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Abstract

Two species of *Pandanus* occur on the remote Christmas Island (Indian Ocean), south of Java (105° 40' E, 10° 30' S), although three binominals have been published. The correct names for the species, a key for their identification, synonymy, and descriptive notes, with illustrations of new or distinctive features, are here presented. *Pandanus christmatensis* is shown to be a member of subg. *Pandanus*, sect. *Pandanus*, closely related to *P. tectorius* Park., and especially so to *P. platycarpus* Warb. *P. elatus* is shown not to be a member of sect. *Pandanus*, as previously stated, but rather, in sect. *Roussinia* (of subg. *Rykia*), previously considered monotypic with *P. leram* Jones ex Fontana. Several critical features, including the hair-tufted anther apiculi, shared by *P. leram* and *P. elatus*, reveal their close relationship.

Introduction

According to Murray's Introduction in Andrews' *Monograph of Christmas Island* (1900), Christmas Island has been known to navigators since about the middle of the seventeenth century. Java, the nearest land mass, is about 190 miles to the north. To the south-west, at a distance of about 550 miles, are the low atolls, the Cocos-Keeling Islands. Christmas Island itself is an ancient, uplifted limestone summit. Its geology is somewhat complex, and basalts and phosphate-bearing rocks are also present. It is the latter which account for the past interest and current industry on the island, phosphate being now the export product. The Island lies in the same latitude, south of the equator, as Fatuhiva in the Marquesas Islands, San Cristobal Island in the Solomon Islands, Cape Delgado on the coast of Mozambique, and is only a short distance south of the latitude of Luanda in Angola and Recife in Brazil. Accordingly it has a fully tropical climate. Christmas Island was shown on a map prepared by Pieter Goos, published in Holland in 1666 (on which it is called Moni). It is not certain who applied the name by which it is presently known. The Island is mentioned by Dampier who visited it in March 1688. Subsequently, it was touched on by several voyagers, but the first real exploration was attempted in 1857 by the frigate H.M.S. *Amethyst*. In 1886 the survey ship *Flying Fish* under Captain Maclear examined it and some specimens of plants and animals were brought home, the first to represent its flora and fauna. Captain Pelham Aldrich called at it in H.M.S. *Egeria* in 1887, and some natural history collections were made by J.J. Lister. In 1888 it was placed under the Government of the Straits Settlements by the visit of H.M.S. *Impérieuse*. In 1890, H.M.S. *Redpole* stopped there for a few hours, allowing H.N. Ridley, of the Botanic Gardens, Singapore, to make some plant collections (Ridley, 1891).

The principal collections from Christmas Island date from the residential work of Charles W. Andrews, who arrived there in July 1897 and remained for nearly a

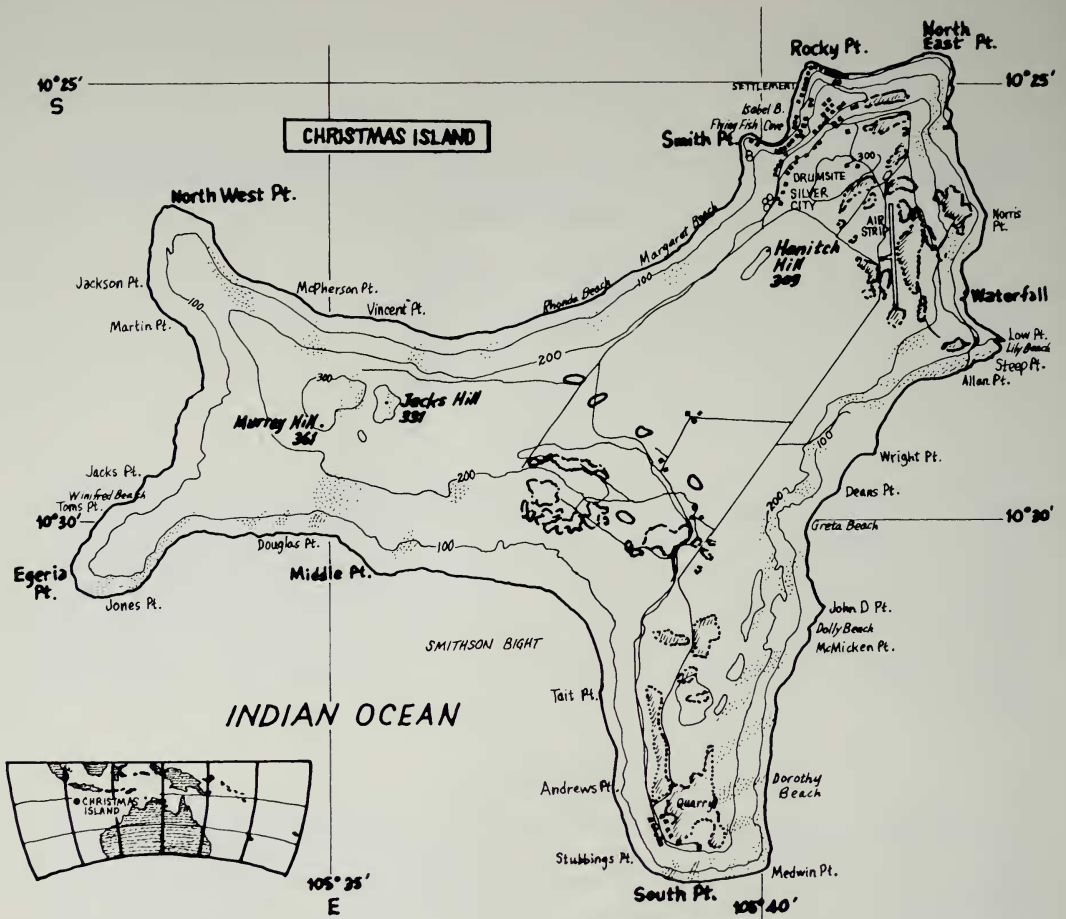


Fig. 1. Christmas Island. from the original which was based on *Atlas of Australia*, Map 159, Reader's Digest Services Pty Ltd. Sydney.

year. In October 1904, Ridley collected there again, later publishing some new species (Ridley, 1906), including two binomials in *Pandanus* discussed further ahead.

The map view of the Island (Fig. 1) may be likened to a standing dog, facing east; its tail is North West Point; its hind leg is Egeria point; its front leg is South Point; and the larger north-eastern part includes the Settlement; the ears are Rocky Point and North East Point, while the muzzle is Norris Point and Low Point, with Waterfall in between. The greatest distance east to west is about 17 km, and north to south about 17.5 km. The highest points are Murray Hill, in the western part (361 m) with Jack's Hill near it (331 m); and Hanitch Hill, in the north-eastern part (309 m). At a distance of 1-3 km inland from the coast, abrupt steep cliffs rise which border the interior plateau, which slopes gently to the south and west. Its surface has shallow valleys and low ridges. The margin is often marked by limestone pinnacles.

The soil is mostly (apart from the reefs and pinnacles) a brown loam strewn with phosphate nodules and often also with fragments of basalt.

The collections of Andrews resulted in the publication of *A Monograph of Christmas Island* (Andrews, 1900) and this embodied the studies of several botanists and zoologists, mostly of the British Museum (Natural History) staff. In the *Monograph*, the enumerated flora contained 111 species of Dicotyledons, 18 of

Monocotyledons, 22 of Pteridophytes, 8 of Bryophytes, and 31 other lower cryptogamous plants, mostly Fungi, as well as one Gymnosperm (*Cycas circinalis*).

The Genus *Pandanus* in Christmas Island

Andrews collected staminate flowers of one *Pandanus* species during his visit in 1897. This was subsequently described by Martelli (1905), who named it *Pandanus christmatensis*. In 1904 Ridley obtained fruiting collections representing two species which he himself named as new. Of one he also obtained good staminate material.

The Christmas Island pandans were reviewed by St. John (1965). He accepted two species, for which he used the names applied by Ridley, providing full descriptions (and good illustrations) of *Pandanus elatus* Ridl. (fruit and staminate flowers), and of *P. nativitatis* Ridl. (fruiting specimens), based on Ridley's collections in the Herbarium of the Botanic Gardens, Singapore. Although St. John mentions briefly that Martelli had previously described (to Ridley) a *Pandanus* species from the island, he neither reports its name nor attempts to deal with it taxonomically and nomenclaturally, remarking merely that the specimen was "fragmentary, staminate material." This material (i.e., Andrews' collection) was evidently not further studied.

Realizing that further investigation of the Christmas Island pandans was necessary in order to resolve the problem of how many species were in fact indigenous there, I requested full new collections from the Conservation Officer, Mr. D.A. Powell, who responded most helpfully. From him I later received excellent collections and notes, which are cited below and which confirm that there are two indigenous species on the island. The collections made by Mr. Powell and his colleague, Mr. H'ng Kim Chey, represent fruiting and staminate flowering material of both species. With this complete representation, it is now clear that one of the names proposed by Ridley, *P. nativitatis*, must be regarded as a synonym of *P. christmatensis* Martelli. This is the species of the coastal regions. The second, limited to the central plateau, retains the original name proposed for it by Ridley, *P. elatus*.

Key to species

Tree to 20 m tall; pistillate cephalium, when ripe, somewhat oblong-cylindric-ellipsoid, to about 33 cm long, bearing about 100 phalanges; phalanges 7.5-9 cm long, more or less transversely compressed, apex low convex; carpels 4-12, mostly 6-9 per phalange; stigmas large, erect, 3-4 mm long and wide. Staminate spikes 12-20 cm long; staminate phalanges 12-18 mm long, of 15-23 stamens clustered at apex of the long (to 9 mm) column; anthers 3-4 mm long, apiculus c. 0.5 mm, acute, bearing a minute tuft of glandular hairs at the apex. Staminate bracts to 40-50 cm long, apex acute, closely spinulose-margined. *Pandanus elatus*

Shrub or small tree to c. 5 m tall; pistillate cephalium, when ripe, ellipsoid or ovoid-ellipsoid, to about 25 cm long, bearing about 60 phalanges; phalanges 5.5-8 cm long, plump, not compressed, apex rounded to convex; carpels many, usually 15-26 (or sometimes fewer, to 9); stigmas about 1-1.5 mm long and wide. Staminate spikes mostly 7-9 cm long; staminate phalanges fastigate, 15-20 mm long, stamens racemose along the column, the free basal part of the column at most 5 mm long; anthers c. 5 mm long, apiculus 0.5 mm long, acute, glabrous. Staminate bracts to 65 cm long, but the apical part very narrow attenuate and flagellate, at apex with very remotely spinulose margins. *Pandanus christmatensis*

Subg. *Rykia* Section *Roussinia*

Pandanus elatus Ridley

Plate 1, Figs. 2, 3 & 7

Ridley, J. Str. Br. Roy. Asiatic Soc. 45 (1906) 239; St. John, Pacif. Sci. 19 (1965) 113, figs. 215-216.

St. John has provided full descriptions and illustrations of both the pistillate and staminate plants, to which the recently collected specimens conform fully, while providing the basis for some corrections and emendations.

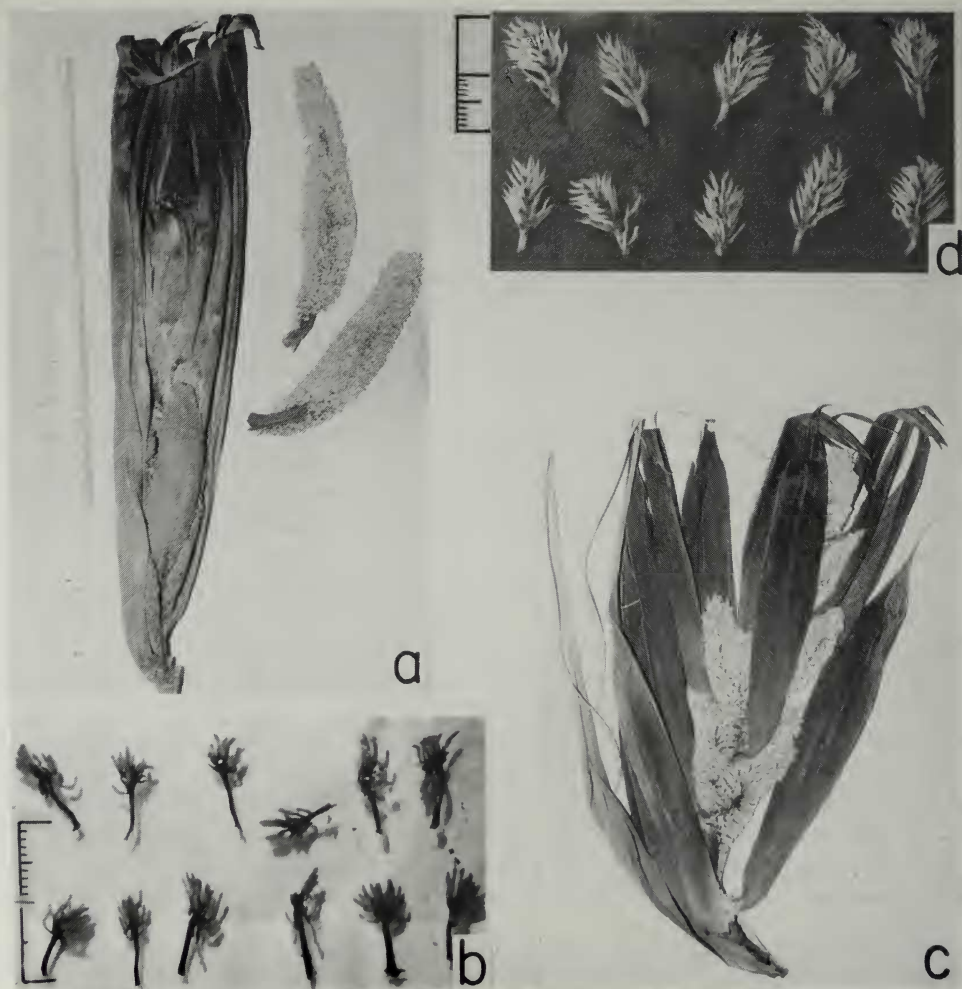


Plate 1. Staminate flowers and inflorescences of *Pandanus elatus* (a, b) and *P. christmatensis* (c, d). a, Part of a staminate inflorescence from Powell & H'ng 10 Oct. 1983; b, staminate phalanges from the same collection. c, Staminate inflorescence from Powell & H'ng Nov. 1983; d, staminate phalanges from the same collection. Scale in b & d show a 2-cm bar with 1 cm divided into mm.

The acute rather than flagelliform apices of the bracts, which moreover have rather densely spinulose margins, are distinctive features that help to distinguish plants of *P. elatus* from those of *P. christmatensis*.

More significant, and not mentioned in St. John's description, are the hair-tufts of the apiculi of the anthers of *P. elatus*. These are formed of glandular hairs and are observed on almost all the stamens. The staminate phalanges bear generally 12-18 (or up to 23) stamens subumbellately arranged on the column apex, which contains usually 4 or 5 vascular bundles in a single circle, and lacks crystal cells, as seen in the cross-sectional view (fig. 3B). The papillosity referred to by St. John said to occur on the column and filaments is an artifact; these structures are in fact smooth, and the so-called papillae are probably merely adherent pollen grains. The pollen grains are about $23\ \mu$ long, slightly larger than those of *P. christmatensis*, and the spinules are somewhat more numerous and longer.

The very large stigmas are noteworthy, as well as the usually obvious transverse seriation of the carpels and resulting compression of the pistillate phalanges. The

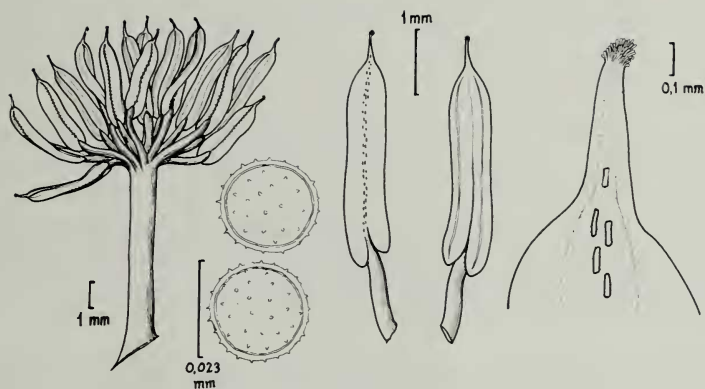


Fig. 2. *Pandanus elatus*, details of staminate structure. Left to right: a complete phalange; pollen; anther, dorsal face; anther, ventral face; anther tip showing tuft on apiculus.

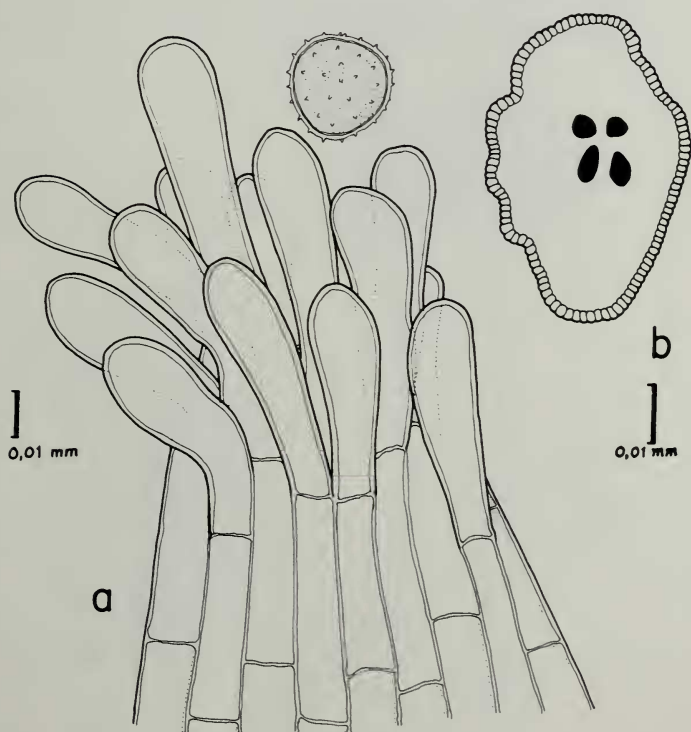


Fig. 3. *Pandanus elatus*, details of staminate structure. a, tip of apiculus, showing the papilliform glandular hairs and one pollen grain. b, Transection at midlevel of one 18-stamened phalange, showing 4 vascular bundles; note absence of crystal cells. Drawn by K.L. Huynh.

outermost carpels appear sterile, their loculi being smaller and lacking endosperm. Often there are only two or three loculi with normal endosperm. The phalanges not infrequently have adherent, imperfect, small peripheral carpels or ferulae (as is true also of *P. christmatensis*).

LECTOTYPE. *H.N. Ridley* in October 1904, Christmas Island, plateau (SING). Isolectotype in K. Staminate paratype: *H.N. Ridley* in October 1904, Murray Hill track, Christmas Island (SING).

RELATIONSHIPS. *Pandanus elatus* was placed in subg. *Pandanus* sect. *Pandanus* by St. John (1965), clearly on the basis of the pistillate phalanges only. The species was overlooked by Martelli who omitted it in his *Enumeration* of species in *Webbia* 4, 1 (1913).

Pandanus elatus differs from authentic members of section *Pandanus*, such as *P. tectorius*, *P. odoratissimus*, and *P. christmatensis*, in several respects, including the compression of the pistillate phalanges, subumbellate arrangement of stamens, arrangement of the vascular bundles in the column, and the papillae or hair-tufts of the anther apiculi. These features exclude *P. elatus* from section *Pandanus*. On the other hand, three of the features are to be found in *Pandanus leram* Jones ex Fontana, a species of the Andaman and Nicobar Islands with an occurrence in South Java (Nusa Kambangan Island, off Tjilatjap), and of the Maldiv Islands. This species is cultivated in Sri Lanka and elsewhere (Stone, 1977). In *P. leram*, the compression of the pistillate phalanges, with more or less clear transverse seriation of the carpels, the large stigmas, and similar leaves and branching habit are to be found, as well as the staminal arrangement and apicular hair-tufts of *P. elatus*.

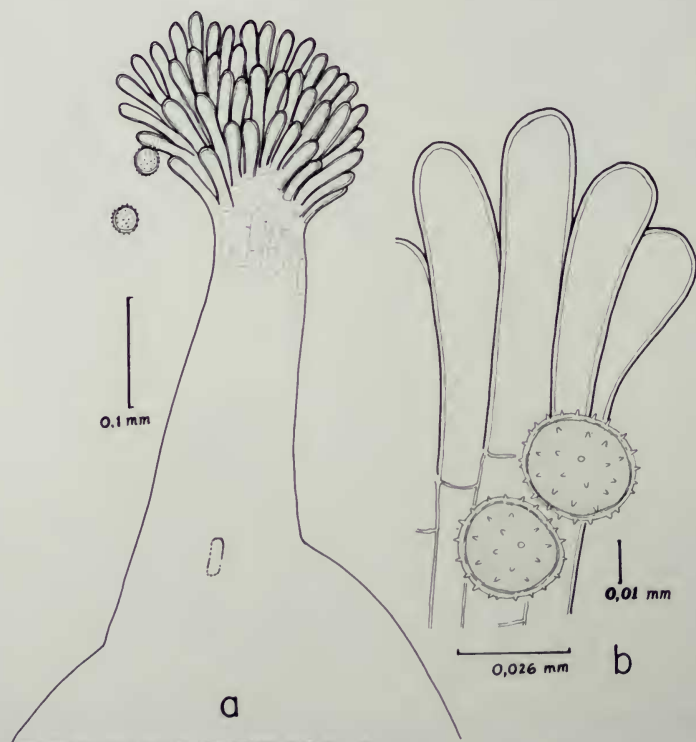


Fig. 4. *Pandanus leram*, details of staminate structure. *a*, Anther apiculus, showing tuft of hairs at tip, with 2 pollen grains; *b*, enlarged view of tuft hairs and pollen grains. From Stone 11102 (KLU), Sri Lanka.

However, the column contains somewhat more numerous vascular bundles which, moreover, are usually in two circles not one. The pollen grains of *P. leram* are slightly larger than those of *P. elatus* (c. $26\ \mu$ rather than c. $23\ \mu$).

Pandanus leram is the sole member of sect. *Roussinia* (Gaudich.) Stone (Stone, 1983). The perceptible similarity of *P. elatus* based on vegetative, foliar, fruit, and staminate characters, indicates that *P. elatus* must be assigned to section *Roussinia* as a second member. On geographical grounds also, this relationship is plausible.

The hair-tufts of the stamens are not restricted to this section; they also occur in a number of other species in several different sections, including sections *Asterodontia* (subg. *Rykia*), *Barrotia* and *Brongniartia* (subg. *Lophostigma*).

Pandanus elatus is endemic to Christmas Island, limited to the high limestone plateau. It is most similar to *P. leram* var. *andamanensium* (Kurz) Stone.

Subg. *Pandanus* Section *Pandanus*

Pandanus christmatensis Martelli

Plate 1. Figs. 5-7

P. nativitatis Ridley, J. Straits Branch, Roy. Asiat. Soc. 45 (1906) 238. St. John, Pacif. Sci. 19 (1965) 116, f. 217.

To the description provided by St. John can be added the following emendations and alterations.

The pistillate cephalia are ovoid-ellipsoid, up to about 22×21 cm (when dried), on peduncles at most 2 cm diameter. There are about 55-70 phalanges per cephalium. The phalanges are distinctly polycarpellate, with about 18-21 carpels being the usual number per phalange, though those with both more numerous (to 26) and fewer (to 9) can be found. St. John's description was based on only three phalanges. In the recent collections the phalanges are about the same size or slightly larger, the apical surface is usually somewhat more convex, but in other respects there is good agreement.

The staminate inflorescences are typical for species of sect. *Pandanus*, the lower and transitional floral bracts being distally protracted into flagelliform tips; these

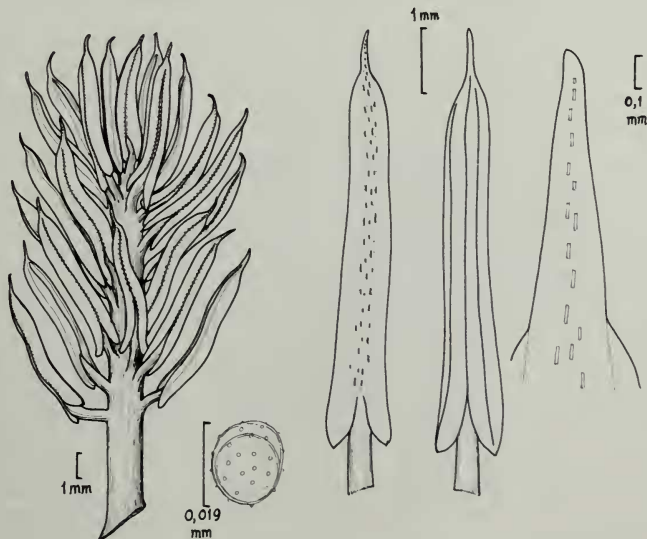


Fig. 5. *Pandanus christmatensis*, details of staminate structure. Left to right: one complete phalange; pollen grain; anther, dorsal face; anther, ventral face; tip of apiculus. Note distribution of raphide cells (small rectangles).

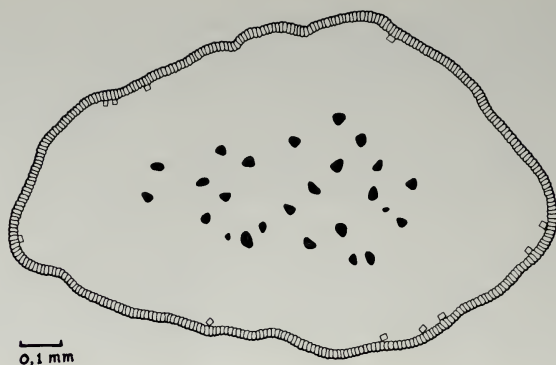


Fig. 6. *Pandanus christmatensis*. Transection at midlevel of column of 31-stamened phalange, with 25 vascular bundles. Note occurrence of crystal cells (small squares) just below epidermis. Drawn by K.L. Huynh.

have sparse and remote marginal spinules. The spikes are comparatively short, up to about 10 cm long. The phalanges are dense, about 15-20 mm long, composed of 15-32 stamens, racemously arranged along the column, only the base (4-5 mm) of the column free; the anthers are about 5 mm long, with a distinct acute apiculus c. 0.5 mm long, the tip of which is smooth and glabrous.

The pollen grains are about $19\ \mu$ long, slightly smaller than those of *P. elatus*, with fewer and somewhat shorter spinules.

The column contains several vascular bundles (fewer than the number of stamens), which are arranged in 2 or 3 circles, as is typical in sect. *Pandanus*. Several crystal-cells are to be seen beneath the epidermis (fig. 6) in cross-sectional view. Each crystalliferous cell contains a single crystal.

HOLOTYPE. Christmas Island, C. W. Andrews in 1897, staminate flowers (BM). Original citation: HAB. Christmas Island nell'Oceano Indiano (Andrews in Herb. British Museum); Martelli, 1905, 1.c. No other specimens cited. Type of *P. nativitatis* Ridley: H.N. Ridley in October 1904, Waterfall, Christmas Island (Indian Ocean), in SING.

The relationships of *P. christmatensis* are clearly with the core species of subg. *Pandanus* section *Pandanus*, including the type species, *P. tectorius* Park. ex Z.; but more particularly with a taxon named *P. platycarpus* Warb., said to be from Zanzibar (though this was disputed by Martelli, who considered it to be from Java)*, the type specimen, collected by E.H.L. Krause, was illustrated by Martelli (1913) in t. VII; and what is possibly the same taxon is shown in a photograph captioned "*P. tectorius* Sol." as figure 6 in van Steenis's *Flora Malesiana* sample treatment, ser. I, vol. 2, *Pandanus in Malaysian vegetation types* of 1954. Also quite similar is the taxon named *P. intraconicus* St. John from Aldabra Island (see the illustration figure 334 in *Pacif. Sci.* 18 (1974) 96-97). This in turn matches pretty well with a collection from Cocos-Keeling Atoll (with an unpublished specific name) made by H. St. John, no. 26414, in the Bishop Museum, Honolulu. The phalanges of this latter collection match so well with those of *P. platycarpus* that I

* Martelli published his view that *P. platycarpus* was not a native of Zanzibar in the *Atti Soc. Toscana Sci. Nat.* 42: 57-59, 1933. He apparently compared Krause's specimen to material from Java and assumed that the plants seen by Krause were not native (either introduced or spontaneous but presumably ephemeral). This is possible, but since closely related species such as *P. kirkii* are clearly indigenous along the East African coast, the actual occurrence of *P. platycarpus* in Zanzibar does not appear in doubt.

would not hesitate to regard them as of the same species; phalanges of *P. intraconicus* differ in the somewhat more prominent carpel tips; while in *P. christmatensis*, the phalange apex is more rounded, the carpel tips still more prominent, the sides of the phalange are not scarred so much, and the lateral sutures are more obvious. These are nonetheless all quite similar, and it is noteworthy that all occur in a latitudinal belt only some 5° wide but about 60° in longitudinal extent (or a little more if Zanzibar is included), across the middle of the Indian Ocean. Of interest too is the record of "*P. tectorius*" from Rodriguez Island, illustrated by Martelli (1913) in tab. 2, fig. 6), which although not the same as the species mentioned above, appears approximately in the same drift zone (but about 5° farther south).

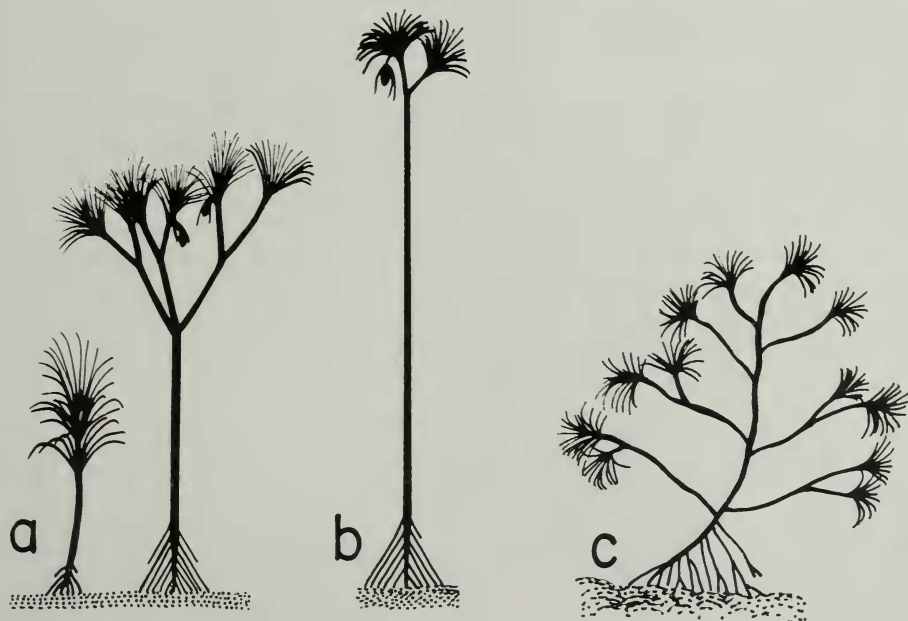


Fig. 7. Habit silhouettes of 3 *Pandanus* species: a, *P. elatus*, juvenile and adult; *P. leram*, modified from Gaudichaud's illustration of *Roussinia indica*. c, *P. christmatensis*. a & c from photographs by D.A. Powell.

Differences in Habit (Fig. 7)

Habit and branching pattern in *Pandanus elatus* and *P. christmatensis* differ. In the former the young plant remains unbranched for some considerable time, and may reach a height of as much as 12 or 13 m before branching, depending on the canopy height of the surrounding vegetation. Branching is somewhat sparse, usually a trichotomy, and the branches themselves di- or tri-chotomously branched in due course. The main trunk remains quite erect, and the proproots tend to form a fairly compact inverted cone 1-1.5 m high. In habit, *P. elatus* further reveals its affinities, this pattern of growth being found not only in *P. leram* (see the habit sketch in the original illustration of *Roussinia indica* Gaudich., Bot. Voy. Bonite Pl. 21, f. 1, 1843), but also in other species in subg. *Rykia* (e.g. *P. furcatus* Roxb., *P. houllettei* Carr., *P. lais* Kurz, etc.).

In contrast, the habit of *P. christmatensis* is, as in its relatives, more fruticose, the trunks branching at a comparatively early stage, with the branches tending to be more spreading, more irregular, the trunk continuing but not so straight, and the proproots often supporting the leaning or even partly horizontal base of the trunk, themselves often branching and interwoven. The overall appearance is thus very

much like that found in *P. tectorius*, *P. odoratissimus*, *P. kirkii*, and other species of sect. *Pandanus*.

These habit characters, supplemented by the habitat differences, thus permit not only the recognition of the species, but lend further support to the allocation of *P. elatus* to sect. *Roussinia* of subg. *Rykia*, and of *P. christmatensis* to sect. *Pandanus* of subg. *Pandanus*.

Acknowledgements

Examination of the anatomy of the staminal columns in flowers of *Pandanus elatus* and *P. christmatensis* was undertaken by Dr K.L. Huynh (Institute Botanique, Universit de Neuchatel, Switzerland), who also prepared figures 4b and 6, and suggested several valuable emendations to the text. This cooperation is gratefully acknowledged.

Much of the original stimulus in studying the species reported on here is the result of the letters, photographs, and collections of D.A. Powell and H'ng Kim Chey. Additional photographs by them will be found associated with the herbarium sheets in K, KLU, and PH.

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